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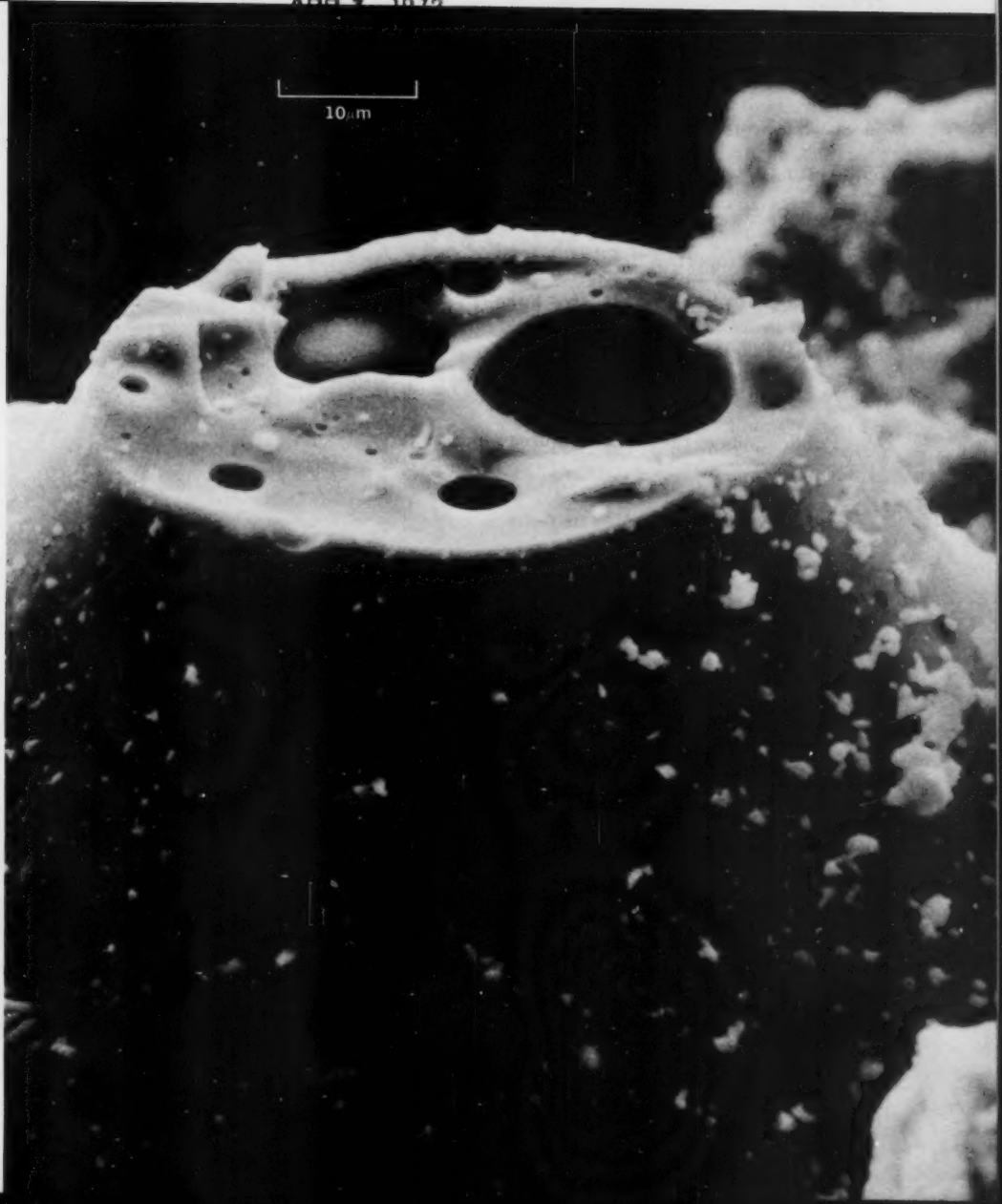
NATIONAL BUREAU OF STANDARDS

Technical News Bulletin



UNITED STATES DEPARTMENT OF COMMERCE

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Technical News Bulletin
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CONTENTS

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Cover: The NBS scanning electron microscope was used by David Ballard in a study of lunar samples collected by the Apollo 12 mission. Shown here is a glassy globule containing iron, magnified approximately 2,250 times. See page 60 for a description of the microscope and more of its applications.

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James H. Wakelin, Jr.
Assistant Secretary
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NATIONAL BUREAU OF STANDARDS
L. M. Branscomb, Director

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

Center for Radiation Research

Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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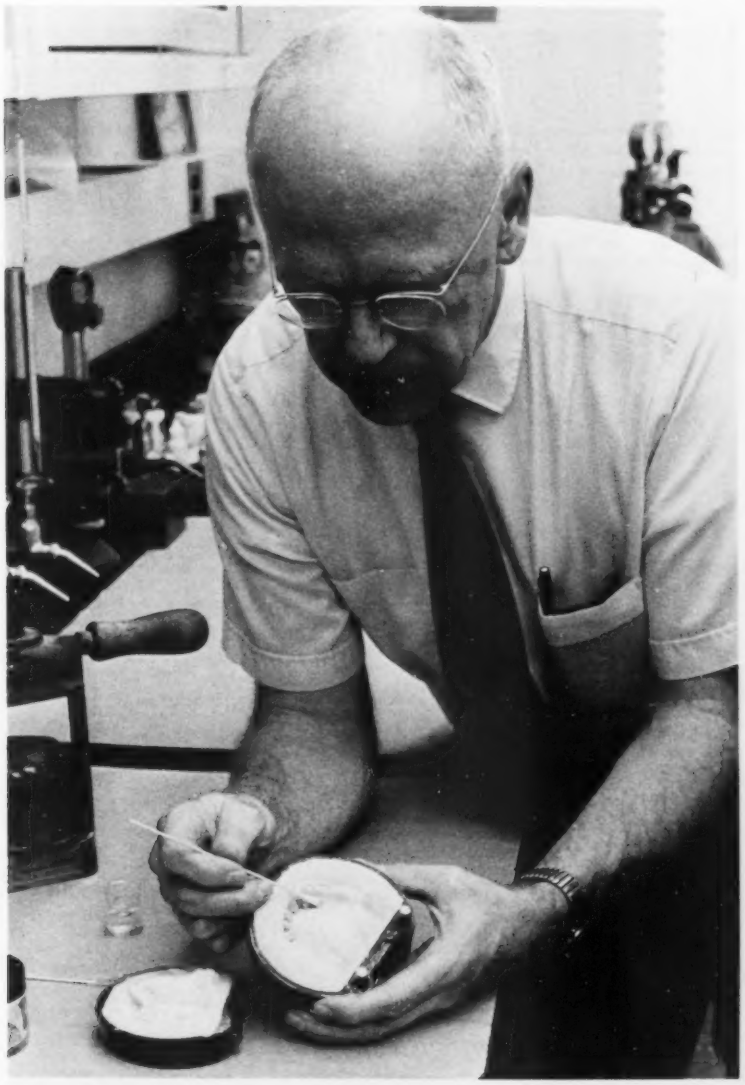
STRONGER BONDS BETWEEN PLASTIC TEETH AND DENTURE BASES

Dr. Rupp is shown applying a test solution to a set of acrylic resin teeth. After the exposure time elapses, any excess solution will be removed and the cold-cured acrylic resin denture base will be formed around the teeth.



Plastic teeth are currently preferred by many dentists. However, previously used bonding methods have not proved successful when applied to the pour-resin technique for processing denture bases. In attempts to alleviate this problem, researchers at the Bureau, in work sponsored by the American Dental Association, developed a procedure that bonds acrylic resin teeth to cold-cured, acrylic resin, denture-base materials. Drs. N. W. Rupp, R. L. Bowen, and G. C. Paffenbarger treated the plastic teeth with a 1:1 solution of methylene chloride and methyl methacrylate monomer for 4 minutes.[1] The resulting bond strength exceeded by 36.8 percent the minimum value for bonding required in American Dental Association specifications. As the teeth become an integral part of the base, there is an increase in denture-base strength and in tooth retention. The bonding procedure requires no more time or equipment than currently used techniques.

Mechanical retention—the procedure of grinding grooves in the ridge lap portion of the tooth—is the most commonly used method of securing acrylic resin teeth to a denture base of cold-cured poly(methyl methacrylate), PMMA. This is time-consuming and adds no strength to the base. Manufacturers of the plastic teeth have recommended that the tooth surface be softened with cold-curing methyl methacrylate (MMA) to establish a bond. Use of this procedure produced tensile strength results

continued on page 69

"PLASTIC" MATERIAL SENSES
INFRARED RADIATION
PYROELECTRICITY FOUND IN FLUORINATED VINYLS

Julius Cohen mounts a specimen of polarized polyvinyl fluoride sheet to a heat sink aperture disk for use as an infrared sensor. Thermal, mechanical, and electrical stressing make this material sensitive to infrared radiation.

Julius Cohen prepares to test a polyvinyl fluoride device for sensitivity to infrared radiation, using a 500 K blackbody source (left).

Recent experimentation at NBS shows that a simple treatment can convert polyvinyl fluoride—a common plastic used in packaging and toys—into a sensitive detector of infrared radiation. Julius Cohen, Seymour Edelman, and Carol Vezzetti, of the Institute for Applied Technology, produced polyvinyl fluoride having an electrical response to infrared radiation by subjecting it to repeated applications of pressure, heat, and dc voltage.[1] Their present work is directed to the use of treated film as the sensing material in detectors that can be made at a fraction of the cost of conventional crystal detectors. These sensors would be sensitive, rugged, easily made in large areas or in arrays covering large areas, would require no cooling in use, and may have a frequency response superior to other thermal detectors. Such characteristics would make them suitable for a variety of applications, including fire detectors and infrared image tubes.

Carol Vezzetti prepares a specimen of polyvinyl fluoride sheet to be simultaneously heated, subjected to an intense electrical field, and squeezed by the press in the background. Polyvinyl fluoride stressed in this way becomes sufficiently sensitive to infrared radiation for use as a sensor.

POLYMER TRANSDUCERS

The Bureau's electronic technology laboratories have been engaged in research on polymers treated to obtain piezoelectric properties, a characteristic previously known but not exploited.[2] The piezocharacteristics are formed by rolling the material and then simultaneously applying a high dc voltage, pressure, and heat. These forming conditions were found to produce pyroelectric characteristics as well, in some polymers. In the present work, pressure, heat, and a dc voltage are applied to polarize the material and thereby create sensitivity to infrared radiation.

The NBS team processes polyvinyl fluoride by clamping a sheet of it between the plates of a hot (60 °C) press (800 N/m²) and subjecting it to an electrical field of 6×10^6 V/cm for approximately 1 hour. This process is repeated for 3 consecutive days.

Devices are formed by cutting out squares of approximately 2.5 cm and constructing a "sandwich" from two pieces. Tests of such a sensor, irradiated from a 500 K blackbody source, show its detectivity to be 4×10^8 cm $Hz^{1/2}/W$ and its responsivity to be 0.1 V/W (both at 25 Hz), with a response time of the order of a few seconds. Subsequently, by improving the construction, polarizing technique, and electronics, large improvements in performance approaching that of conventional crystal pyrodetectors were achieved in polyvinyl fluoride and polyvinylidene fluoride as well.

[1] Cohen, J., Edelman, S., and Vezzetti, C., Pyroelectric effect in polyvinylfluoride, Nature Phys. Sci. **233**, 12 (Sept. 6, 1971).

[2] The piezoelectric effect in polymers/Rolled polyvinylchloride and polyvinylfluoride equal quartz, Nat. Bur. Stand. (U.S.), Tech. News Bull. **55**, No. 10, 240, 259 (1971).

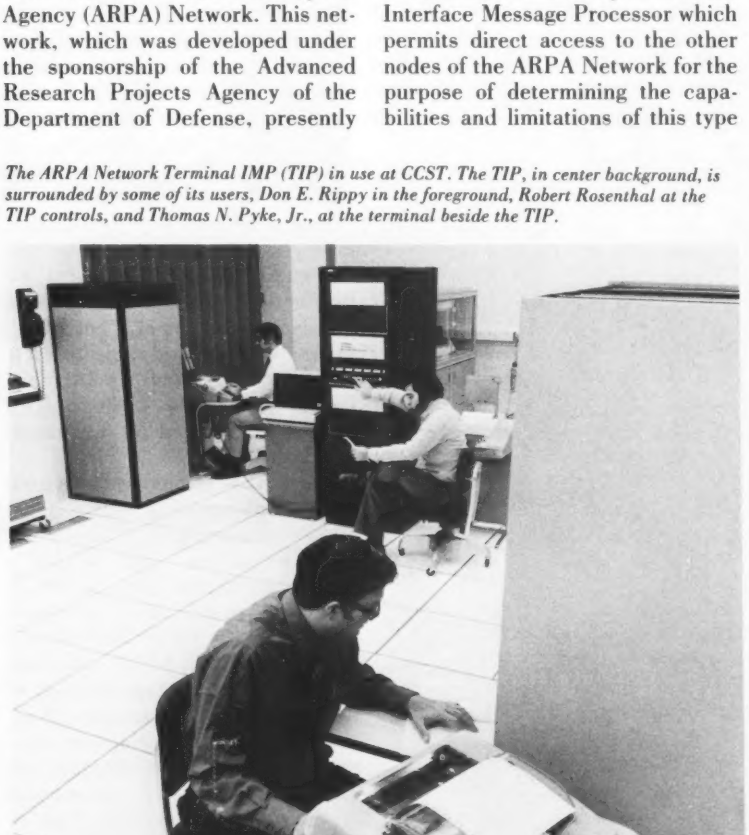
CCST NEWS

NBS CONNECTED TO ARPA NETWORK

In December 1971, the NBS Center for Computer Sciences and Technology (CCST) became a node of the Advanced Research Projects Agency (ARPA) Network. This network, which was developed under the sponsorship of the Advanced Research Projects Agency of the Department of Defense, presently interconnects 24 computers at 18 sites throughout the United States. Most of these sites are at universities and other research-oriented organizations having computer science programs.

The CCST has set up a Terminal Interface Message Processor which permits direct access to the other nodes of the ARPA Network for the purpose of determining the capabilities and limitations of this type of data network to service the future demands of Federal agencies. Access to the network through the NBS node will be encouraged for other Federal agencies in the eastern part of the country in addition to NBS internal usage. During such utilization of computers on the ARPA Network by other agencies, CCST staff will work with these users to determine how well the network satisfies their demands. A significant part of CCST activity will be the application of performance measurement tools, including the CCST Dialogue Monitor, to attempt to quantify where possible the parameters associated with network-demand satisfaction for these users.

The ARPA Network Terminal IMP (TIP) in use at CCST. The TIP, in center background, is surrounded by some of its users, Don E. Rippy in the foreground, Robert Rosenthal at the TIP controls, and Thomas N. Pyke, Jr., at the terminal beside the TIP.



The ARPA Network is a buffered store-and-forward data network that connects a set of geographically separated heterogeneous and autonomous computers, called "hosts," with a design objective of facilitating interactive resource sharing between any set of these hosts.[1] The store-and-forward processing is performed by a set of identical small computers called Interface Message Processors (IMP) connected by 50,000 bit/second common-carrier circuits. However, the internal operation of the store-and-forward network utilizing the IMPs is self-contained and essentially transparent to the individuals using the resources of the network. It should be possible for an individual, such as a programmer or researcher, with access to the network to use the resources of any of the host computers as if they were available in an extended local host computer.

Resource sharing can take place

when individuals at sites in the network become familiar with the resources available at other host sites. Resources of interest at each host site include the computer(s), peripheral equipment, existing programs, data bases, and the specialized talents of personnel. Besides providing communication between terminal users and host computers on the network, the ARPA Network permits flexible computer-to-computer communication at relatively high data rates.

CCST has installed a Terminal Interface Message Processor, or Terminal IMP (TIP), which, in addition to providing a store-and-forward function for the network and a connection for a local host computer at NBS, permits direct connection of up to 63 interactive terminals to the network. In the configuration at NBS, a variety of teletypewriter and cathode-ray-tube display terminals have been directly attached to the TIP to facilitate CCST network use. A number of datasets have been configured between the TIP and the direct-dial network to permit other Federal agencies having interactive terminals to dial into the CCST TIP, and from there to connect to any host system on the network.

In addition, CCST has installed a minicomputer configuration that can operate as a host computer connected through the TIP to the network. Besides providing a flexible interface to the network for a wide range of terminals, including remote batch terminals, this minicomputer will be used to implement the various performance-measurement tools that will be applied as users access the network through the CCST TIP.

GOVERNMENT-WIDE COBOL VALIDATION SERVICES PLANNED

Through cooperative management of the major agencies involved in the implementation of Public Law 89-306 (the Brooks Bill), plans are being initiated for establishing Government-wide testing services for validating COBOL compilers. As currently planned, the Office of Management and Budget will provide management direction and policy guidance of the validation service. The Center for Computer Sciences and Technology will develop criteria for measuring compliance of COBOL compilers with the Federal Standard and will monitor the Government-wide validation service. The Department of Defense will implement and maintain COBOL test routines and will provide Government-wide test services for COBOL compilers. The General Services Administration will issue procedures and instructions concerning COBOL validation in future procurements.

The validation service, which is planned to be operational within the next few months, is expected to facilitate better procurement of COBOL compilers by the Government and to improve computer utilization during the life of the COBOL compiler through increased quality control. Further, validation is expected to assure adherence to the Federal COBOL Standard, now awaiting approval by the Office of Management and Budget. Establishment of a Government-wide COBOL validation service should also reduce overall costs for such validations now being performed independently by various agencies. Another major aspect of compiler validation is that of improving transferability of application programs written in the COBOL Language among different installations.

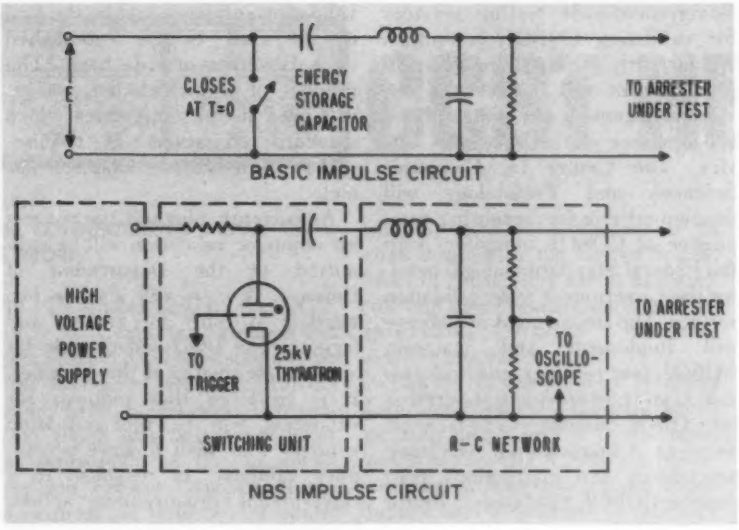
Validation is the process of determining the extent to which a COBOL compiler conforms to certain conditions or requirements. In this case, these conditions and requirements are specified in the Federal COBOL Standard. Validation services are an essential ingredient of effective computer utilization by Government departments and agencies. The COBOL validation service would be the first of its kind to be established on a Government-wide basis. The product of the validation process will be a listing that states which standard conditions or requirements each tested compiler has met.

As currently planned, the request for compiler validation will be submitted to the Department of Defense. A copy will also be forwarded to NBS for review and logging. The DOD will provide for appropriate testing of the compiler. It is expected that requests for validation will be received from vendors who wish to have a compiler validated in response to a Government procurement action, from agencies involved in procuring a COBOL compiler, and from agencies desiring to verify a COBOL compiler which has already been acquired and is currently in use. The requester of the validation service is responsible for supplying necessary descriptive documents in order to identify the compiler validation requirements. Also, the requester is responsible for supplying any necessary test facilities. The results of the tests will be released to the requester for his use. COBOL compilers that are acceptable without further modification will be reported to the National Bureau of Standards and the General Services Administration. The validation routines along with associated documentation will be available to vendors and others on a time-and-materials cost basis. Federal agencies will be responsible for reporting to NBS on the utilization of compilers that have been validated.

The cost of a particular validation shall be borne by the requester. The DOD will develop cost arrangements with the requester prior to providing the validation service.

The process of validation determines the extent to which a COBOL compiler satisfies specified test

continued on page 68



The lightning arrester impulse testing circuit, a modification of a basic impulse testing circuit, uses a high-voltage thyratron for switching, rather than a spark gap or a mechanical switch.

TESTING GAS-TUBE LIGHTNING ARRESTERS

NEW CIRCUIT FOR IMPULSE TESTING

A circuit has been designed for impulse testing of gas-tube lightning arresters. D. Hillhouse, of the High Voltage Measurements Section, designed and tested the new circuit to measure characteristics of arresters for the Rural Electrification Administration (REA), which provides engineering specifications for power and telephone systems that it backs. The adjustable circuit supplies linear voltage ramps that rise at rates from 0.5 to 10 kV/μs.[1]

Telephone systems are commonly protected from lightning damage, and their users protected from injury, by lightning arresters installed at exchanges and at the subscribers' premises. The REA establishes specifications, including those for arresters, for telephone companies financed by it and also influences specifications for the telephone systems of the U.S. Armed Forces and of some developing countries.

Lightning arresters consisting of air gaps between carbon blocks have been widely used as breakdown routes to ground lightning energy. Such arresters are now being replaced in many applications by the longer lived gas-tube arrester, which contains two electrodes in a noble gas mixture. Such a tube conducts when its breakdown voltage is reached, but this voltage has been found to rise with increasing wavefront steepness. Needed was an apparatus for testing arresters over a range of pulse rise rates simulating lightning.

DESIGN AND OPERATION OF TEST CIRCUITS

The basic lightning arrester test circuit used by NBS consists essentially of a voltage source (storage capacitor), a triggering device (switch), and an RLC waveshaping circuit across which the arrester under test is connected. The variation developed by Mr. Hillhouse employs an electronic high-voltage supply as the source, a thyratron tube as a shorting switch, and a measuring network as the resistive component of the RLC circuit. Network divider ratios are chosen to provide an input to the plates of an

oscilloscope, so that a photographic record can be made of the charge-breakdown waveform.

The circuit is used by connecting the test arrester in parallel with the measuring divider and energizing the power supply. With the thyratron nonconducting, the storage capacitor is charged slowly to the full power supply voltage through a charging resistor. A trigger pulse causes the thyratron to conduct, in series with the storage capacitor and the waveshaping and measuring network, applying a voltage ramp to the arrester. The charging resistor isolates the power supply from the shorted thyratron. When the arrester breaks down, the capacitor is discharged very rapidly and the thyratron switches off, restoring the circuit to its initial condition. The capacitor automatically recharges through the charging resistor, after which the cycle can be repeated by once more triggering the thyratron.

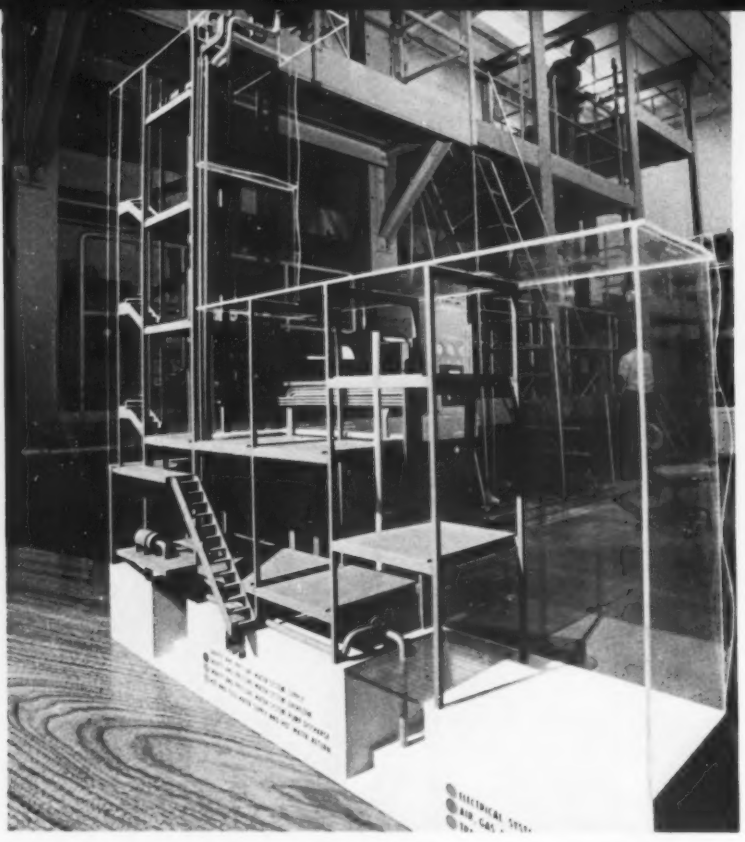
"SLOW" VERSUS "FAST" CIRCUITS

Since lightning traveling on telephone lines may result in voltage variations between a few hundred volts per microsecond and 10 kV/μs, it is desirable to be able to test arresters at more than one rate of rise. This can be done by selection of the proper values for the waveforming network. Mr. Hillhouse selected values that produced either a slow rise of 0.5 kV/μs or a fast rise of 10 kV/μs. When the measured rate of rise was compared with the rate calculated for the values of the circuit components chosen, excellent correspondence was found for the slow circuit up to a rate of 2.6 kV/μs and for the fast circuit at rates of 7.5 to 10.5 kV/μs. The maximum voltage breakdown errors from all sources are believed to be 3 percent at 0.5 kV/μs and 10 percent at 10 kV/μs, both for a breakdown voltage of 500 V.

[1] Hillhouse, D. L., Circuit for impulse testing of gas-tube lightning arresters, Proceedings, 1971 IEEE Fall Electronics Conference, Oct. 18-20, 1971, Chicago, Ill., pp. 240–245.

David Hillhouse attaches test leads to a lightning arrester assembly from an impulse testing circuit designed at NBS. The circuit, which simulates lightning surges on telephone lines, is enclosed in clear plastic to guard the operator from electrical shock.

David Hillhouse and Walter Mangan (left) operate an apparatus for high-voltage testing of gas-tube lightning arresters for telephone systems. The test circuit was designed at NBS for impulse testing with varied rates of voltage rise.



A model of the new NBS plumbing research facilities is shown in the foreground, and the first two stories of the actual facilities in the background.

NEW FACILITIES FOR PLUMBING RESEARCH

The Building Research Division recently installed major new facilities for plumbing research in response to the needs of the plumbing industry, city and State regulatory bodies, and Federal agencies. The new facilities are expected to provide research capability for updating plumbing practices in housing and to lead to more economical plumbing systems. The laboratory consists of a medium- and a low-rise tower-type test facility equipped with a modern electronic data acquisition system and supporting instrumentation for retrieving and computer-processing experimental data through the Bureau's central computer. The design of the facilities was derived from the Bureau's long experience in plumbing research and from recent surveys of European laboratories.

The facilities first will be used to meet some of the more urgent needs in the area of plumbing innovations and evaluations for the Nation's housing (and later for other types of buildings). It is anticipated that this work will be supported by a combination of funds from other Federal agencies or industry associations that have a major interest in plumbing engineering or plumbing standards. Extensive exchange of information with Government departments and the industry has determined that several existing or potential programs offer unique opportunities for cost savings and needed improvements in the current criteria and tests for design and evaluation of plumbing systems. Included among these are the following:

- Investigations to update and expand existing criteria for determining safe economic design fluid loads for plumbing under service conditions.
- Studies to establish suitable criteria for evaluating the hydraulic performance of innovative types of plumbing systems such as single-stack and vacuum drainage systems, reduced-size venting, and other simplified piping designs.
- Development of criteria and tests for evaluation of the performance of plumbing piping, with particular attention to the effects of thermal, chemical, mechanical, and corrosion environment.
- Development of updated and expanded criteria for determination of functional effectiveness of plumbing equipment and devices.

The laboratory facility provides for a recirculating water supply at any realistic (up to 80 psig), constant, predetermined pressure under variable demand up to at least 300 gallons per minute. More precisely controlled flow rates under variable demand up to approximately 1,000 gallons per minute can be produced at somewhat lower heads (approximately 25 psig at the base of the tower). Cold and hot water, compressed air, vacuum, gas, and electrical services are provided. A universal instrumentation wiring distribution system has been provided that permits the ultimate in flexibility and ease of data logging, and makes it possible to utilize either the modern high-speed digital data-acquisition system or

standard instrumentation, or to employ both at the same time. This system will be supplemented and serviced by appropriate display and control modules, signal conditioning equipment, transducers, and calibration facilities. The central data-acquisition system has been designed for use in the field as well as to provide long-needed data on all major types of plumbing system loads.

The tower facility is designed to initially accommodate tests of up to five-story systems. Tests of systems up to seven stories in height (7-ft branch intervals) can be made by taking advantage of an adjustable floor-height feature incorporated in the design. The testing facility provides for testing of split-level systems as well as traditional types. The facility is designed to provide for the testing of several systems at the same time, in contrast to serial-type testing. For example, initial tests are to be conducted simultaneously on a simple stack, a split-level design, and a five-story design. Facilities for the performance evaluation of a variety of plumbing devices, fixtures, and appliances, are provided.

The data-acquisition system and associated instrumentation provide a capability for high-speed scanning of signals from up to 256 transducers with selective retention of measured values according to predetermined criteria. The data, automatically preselected for retention, can be processed through the NBS central computer without manual handling or conversion. However, for a limited amount of data processing, for purposes of display, or real-time control of experiments, processing of the data can be accomplished in the laboratory in parallel with testing.

Among the many dynamic variables that can be measured are fluid pressures, velocities and discharge rates of air and water, water surface elevations, temperatures, strains and stresses, accumulated weight, mass-flow rates, linear or rotational movement, chemical concentrations, and dissolved solids content and turbidity.

METHANE PROPERTIES STUDIED

The growing economic importance of natural gas as a fuel and as a raw material for many chemical processes makes it necessary to know more about its physical properties. In particular, the worldwide production of liquefied natural gas (LNG) is increasing rapidly, and the economical production and use of this form of the gas requires accurate data on its thermodynamic properties. Such data is being gathered and analyzed at the Boulder laboratories.

The rapid growth of LNG production is attributed to the fact that LNG is more economically transported in ships and trucks than gas. Where pipeline gas is either nonexistent or becoming scarce, LNG is an attractive alternative and is already supplying an appreciable fraction of the gas needs of several American and European cities. Using LNG as a motor-vehicle fuel may eventually push production to astronomical levels. LNG-powered cars and trucks undergoing tests and evaluation in several cities have been shown to require less maintenance, produce less objectionable emissions, and operate more economically than conventional vehicles.

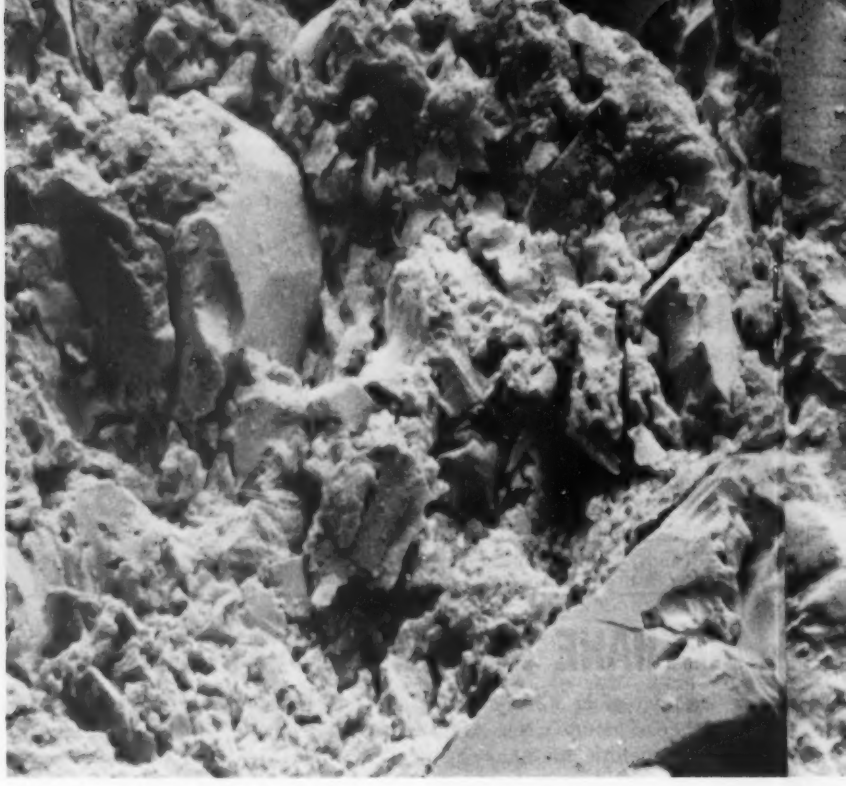
Up to 99 percent of natural gas is methane. By investigating gaseous and liquid methane properties, the NBS Cryogenics Division obtains precise, comprehensive data on specific heats and relationships between pressure, volume, and temperature. From these data the group calculates accurate thermodynamic properties such as enthalpy, entropy, and internal energy. Drs. R. D. Goodwin, R. Prydz, and B. A. Younglove, the principal investigators, operate under an American Gas Association grant. Precision measurements are completed for vapor pressures, melting pressures, and pressure-volume-temperature (PVT) relationships of liquid methane. Future measurements include PVT relations in compressed gaseous methane and specific heat determinations for both gaseous and liquid phases. Temperatures of all these measurements range from 90.7 K (the triple point, where solid, liquid, and gas phases coexist) to 300 K, and pressures vary between 0.1 and 35 meganewtons per square metre (1 $MN/m^2 = 145$ psia).

The Cryogenics Division is also determining the phase equilibrium properties of methane mixed with argon and nitrogen, and publishing the "LNG Quarterly." The Quarterly lists articles and papers from the recent LNG literature and is available by subscription.[1]

The increasing commercial activity in LNG requires better metering techniques for equitable trade. Because LNG is usually boiling when delivered (though its normal boiling temperature is −258 °F) it presents unusual metering problems; e.g., flowmeter design must avoid cavitation effects that destroy accuracy. A concurrent NBS project is investigating flowmeter design to determine the best way to use commercial meters, to discover and evaluate new metering techniques, and to develop more accurate methods for checking flowmeter performance.

[1] $15 per year. Write to LNG Quarterly, Cryogenics Division, National Bureau of Standards, Boulder, Colo. 80302.

Image of dendrites formed on an aluminum-tungsten alloy surface, magnified 6,450 times. The spacing between the dendrites is being used to check the quality and resolution of scanning electron microscopes.

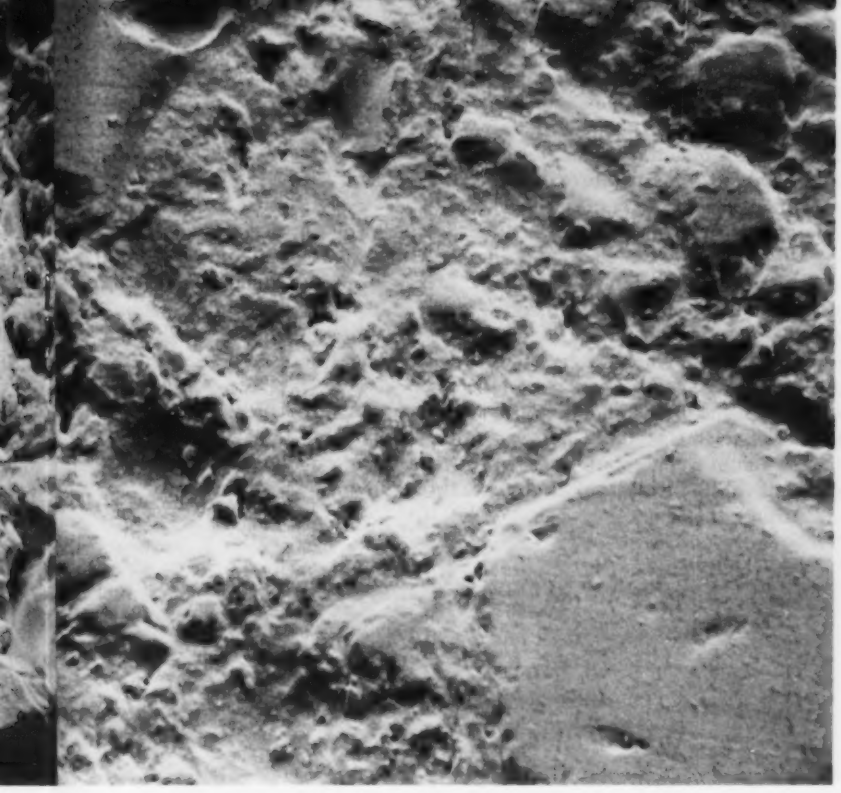


SCANNING ELECTRON M

In the summer of 1969 the Bureau expanded its technological competence with the establishment of a central scanning electron microscope facility. During the past 2 years, scientists throughout the Bureau have used this tool in exploring the surface topography of a wide variety of materials, such as lunar rocks, bridge structure fractures, microelectronic circuits, and tooth restorations. The facility is located in the Institute for Materials Research, with A. W. Ruff, Chief of the Lattice Defects and Microstructures Section, Metallurgy Division, managing its operation, assisted by D. B. Ballard.

The commercially purchased scanning electron microscope (SEM) produces an apparent three-dimensional image of the material's surface. Using a fine electron-beam probe, the SEM can produce images with great resolution (about 25 nm) and considerable depth of focus, far surpassing the optical microscope that usually provides a two-dimensional view of the surface. The large depth of focus is particularly valuable in studies of rough, irregular specimens. The use of stereopair photography, where the specimen is tilted in the microscope between exposures, readily permits three-dimensional examination of the surface features.

Operation of the scanning electron microscope begins by focusing a beam from an electron gun to a spot of about 10-nm (100 Å) diameter on the specimen. The electron beam is deflected by scanning coils across the specimen in synchronism with a cathode-ray-tube scan, producing a raster image of the surface. Secondary electrons, backscattered electrons, and x rays from the specimen are detected and amplified, each providing a signal that can be used to modulate the brightness of a cathode-ray display system. This produces a point-by-point, line-by-line, TV-like image. The ability of the SEM to detect characteristic x rays produced where the electron beam strikes the sample permits elemental chemical analysis studies on a microscopic level. Such analysis is at best semi-



The scanning electron microscope was used to observe the surface of dental fillings that had been polished using various techniques. The photo on the left shows the surface condition of a composite filling material, widely used in dentistry, after finishing with a commercial "super" fine instrument sold for this purpose. At the right is the same surface after further polishing with an experimental paper disk covered with epoxy resin containing 1-5 μm diamond particles. (Both SEM photomicrographs magnified the surface 1,000 times.)

An SEM photomicrograph of the tungsten field-emitter tip of the new NBS "topografiner" shows the tip magnified 1,250 times for examining the quality of the etching process used in producing the tip. Various etch solutions were tried to obtain the sharpest and smoothest possible point.

N MICROSCOPE FACILITY

quantitative in view of the complex problems of x-ray emission and absorption in a typical sample. Although the selectivity of the SEM's x-ray detection system is not as good as that of an electron microprobe using crystal spectrometers, the information obtained may be used in identifying an unknown material.

In comparison with the conventional transmission electron microscope (TEM), the sample preparation procedure is extremely simplified for the scanning electron microscope. A conventional, 100-kilovolt TEM instrument requires either a very thin sample (typically 1000 Å) or a replica of the surface since the electrons must be transmitted through the specimen before being detected. The SEM, however, can observe the surface of any electrically conductive (or suitably coated) opaque or irregular sample, regardless of the thickness, using an image resulting from interactions of the primary electron beam with the specimen. The only size limitation is that the sample fit onto a 2.5-cm, round specimen holder and be less than 1 cm in height. In cases where the sample is too large, a replica of the sample is used.

Over 30 scientists at NBS have been trained to use the SEM. The facility is then made available to them for their own research studies with relatively few restrictions. Some of the highlights of the wide variety of uses to which they are applying the instrument are summarized below.

The instrument's principal operator, D. B. Ballard, is using the SEM to aid in determining the cause of fracture in metallic materials. He has studied a copper-palladium alloy that embrittled rapidly at the grain boundaries in saltwater. This alloy, with other elemental additions, is used to weld copper. As welded copper tubing is incorporated in desalination plants under exceedingly high temperatures and pressures, any fracture is potentially disastrous. The variations of grain-boundary attack in the potentiostatically controlled corrosion of an aluminum alloy were also ob-

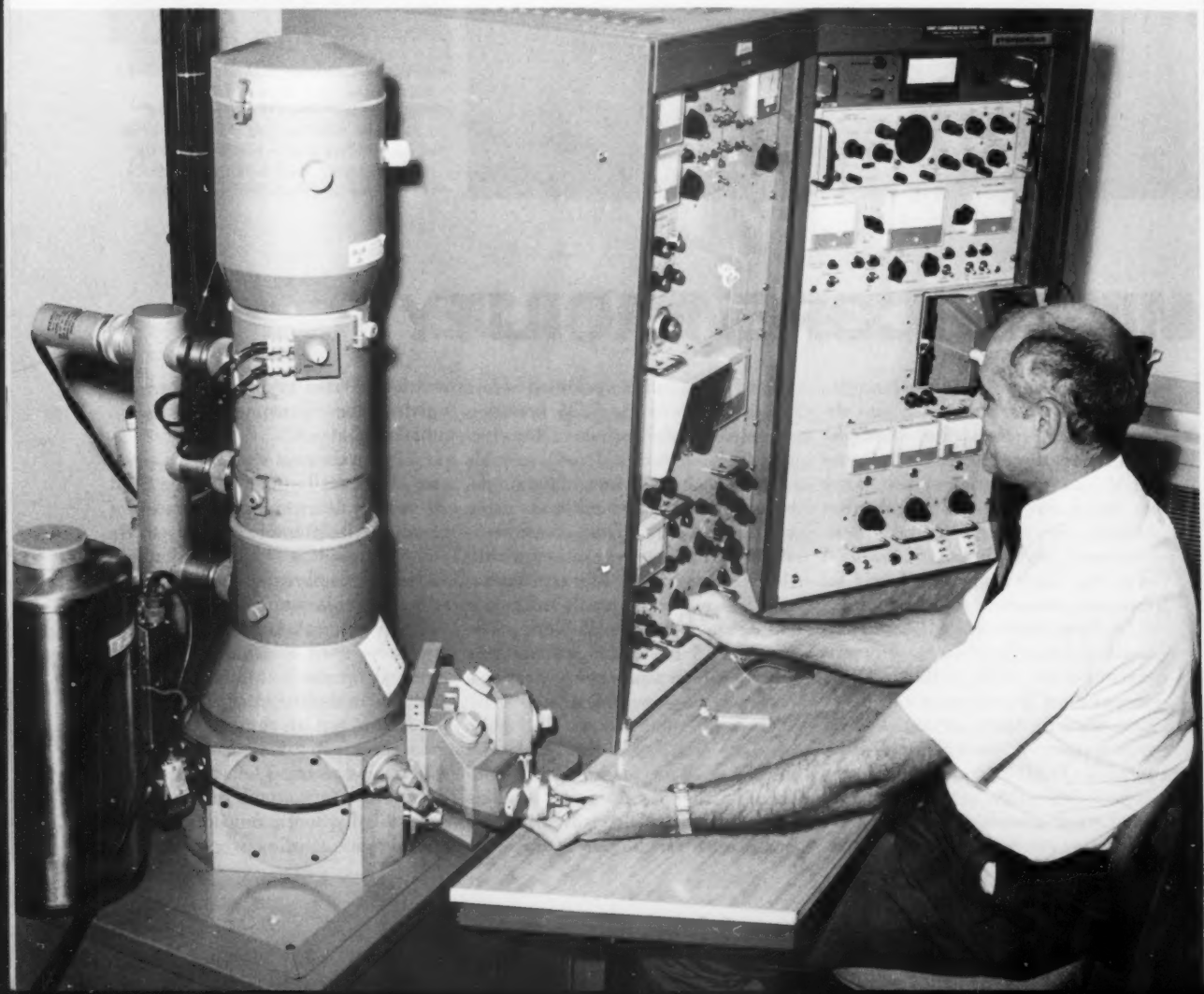
served. In another task underway at present, dendritic formations on the surface of an aluminum-tungsten alloy are being used to check the quality of the resolution of the SEM at magnifications as great as 100,000 times. The use of dendritic formations for this purpose shows great promise because they meet such requirements as having variable and highly contrasting spacing between dendrites, yielding no apparent contaminants to the vacuum system, producing no reaction upon interaction with the electron beam, and enabling accurate adjustment of the SEM stigmator.

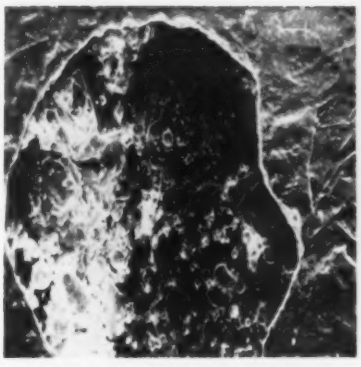
In other work in the Metallurgy Division, metal particles and soil samples from the Apollo 11 and 12 lunar expeditions were examined on the SEM in order to observe and identify lunar material in micrometeorite craters in the specimen, as well as exposed dendrites on the surface. Investigations of metallic inclusions in some samples provided evidence of various degrees of meteoritic shock damage in the metal. The Apollo 11 samples also contained many glassy spherules. Some of these had surfaces which were splattered with metal, identified from x-ray analysis in the SEM to contain iron, nickel, and cobalt.

In a recent examination conducted in the Metallurgy Division, the relative x-ray intensities from silicon, magnesium, and calcium served to distinguish several forms of asbestos, among them chrysotile and termolite. This ability to discern chemical as well as topographical detail makes the SEM invaluable in microscopic particulate studies.

Dental researcher R. L. Bowen of the Polymers Division uses the SEM for providing a magnified, three-dimensional view of the

The scanning electron microscope and its associated electronics are being readied for operation by its principal operator, D. B. Ballard.





This SEM photomicrograph shows the bottom of a defect that manifested itself as rust on an enameled surface. Note the build-up of corrosion products on the bottom of the defect. The original magnification is 700 times.

results of various polishing techniques in a program to improve present methods of finishing dental restorations. Dr. Bowen is also using the SEM in analytical procedures in attempts to improve the strength and durability of composite materials used in filling teeth.

Porcelain enamels, protective coatings for metals, are being used, for example, in shielding the exterior walls of buildings from the corrosive effects of the atmosphere. M. A. Baker of the Building Research Division is employing the SEM in analyzing samples of weathered enameled surfaces to observe the rusting process of the metal where pinholes penetrate the enamel.

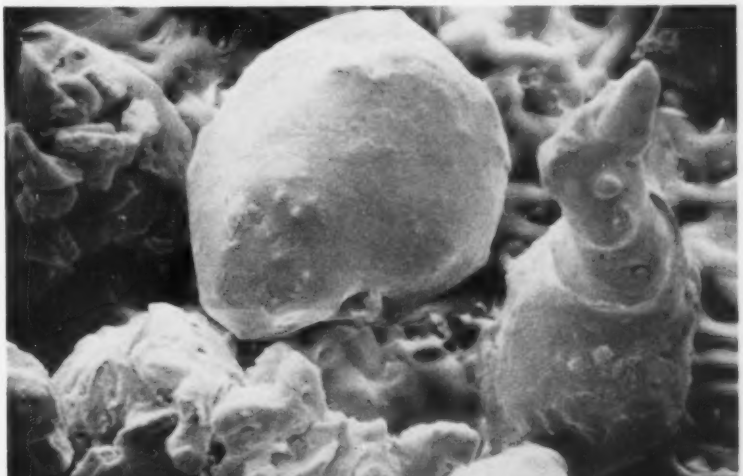
In this age of miniaturization, electronic circuits are made smaller than the human eye can distinguish on very thin wafers of semiconductor materials such as silicon. K. O. Leedy of the Electronic Technology Division is using the SEM to investigate the quality of ultrasonic bonds of wires to microcircuits. W. J. Keery of the same division is studying bumps, holes, or incomplete contacts that have produced defects in microcircuits. He has also used the SEM to determine the degrees of sharpness of cutting tools such as a diamond point used in a scratch test to determine how well the vapor-deposited metal adhered to the ceramic surface, to examine failed transitors to determine points of failure, and to examine the impression of a probe as might be used in making resistivity measurements in a semiconductor.

Balloon catheters are instruments used in the human aorta as a valve and a pump to rest the heart prior to open heart surgery. The catheters are coated with a thin film of hydrogel to make them compatible with the blood. Within the Product Evaluation Technology Division, R. Pierson has been using the SEM to measure the thickness and uniformity of the thin film, hydrogel coating to check for performance and safety.

Within the same division, E. L. Graminski is using the SEM to evaluate the characteristics of currency paper at various stages of production and varying degrees of wear. Different types of wear produce characteristic defects that can best be observed with the SEM. Through a determination of the structural changes that occur with wear, Bureau researchers are working on ways to modify currency paper that will result in increasing the circulation life of paper money.

And as a final note, the SEM is even playing a role in the development of a new instrument that will complement the information obtained with the scanning electron microscope. An electron field emission probe is being used as an electron source in a new instrument called a "topografiner," being developed by R. D. Young and F. E. Scire of the Optical Physics Division. In order to obtain the highest possible resolution with the instrument, the electron probe must emit a very intense beam of electrons, the intensity being dependent on the shape of the tip of the field emitter. The SEM was used to examine the shape of the emitter tip after an etch was used to form the point.

The large depth of focus of the scanning electron microscope is demonstrated in this photomicrograph of stainless-steel powder, magnified 600 times.



NSRDS NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

RADIATION CHEMISTRY DATA CENTER

The Radiation Chemistry Data Center at the University of Notre Dame, Notre Dame, Ind., was established in 1965 with the support of the Office of Standard Reference Data and the Atomic Energy Commission. The Director of the Notre Dame Radiation Chemistry Data Center is Prof. John L. Magee who is also Director of the Radiation Laboratory of the University. The professional staff of the Center currently includes: Dr. W. P. Helman, Supervisor; Dr. A. Ross, Consultant; Dr. Farhataziz; and Dr. L. J. Sharp. The Center's mission is to collect, compile, and arrange for evaluation data from chemical reactions brought about by ionizing radiation. Included in these data are radiation yields and kinetic data on elementary processes in irradiated substances (organic and inorganic, aqueous and nonaqueous solutions, solids, and gases), as well as changes in physical properties of irradiated substances. The Radiation Chemistry Data Center provides replies to inquiries for specific information or data, prepares bibliographies and preliminary compilations on request, and provides critical reviews and critical compilations as well as literature-search assistance to authors of critical reviews. The Center's mechanized literature file contains approximately 13,000 entries, with a growth rate of about 300 items per month. The organization of the Center's files emphasizes storage and retrieval of bibliographic material and descriptions of data rather than the numerical data themselves.

Dr. W. P. Helman, Supervisor of the Notre Dame Radiation Chemistry Data Center, and Mrs. Mary Early discuss a data compilation in progress.

The Radiation Chemistry Center has produced a number of publications. Among its most favorably received is the "Weekly List of Papers on Radiation Chemistry," a current awareness listing of the new entries into its files. The *Weekly List* provides the title, authors, and reference for each item plus the language of the item. The Center has recently produced a semiannual index to the *Weekly List* (see NSRDS News, February 1972). All

of its present publications listed below are currently available from the National Technical Information Service.[1]

COM-71-01103, Weekly List of Papers on Radiation Chemistry, Index and Cumulation, Vol. IV, Nos. 1-26, Jan. through June 1971, by Radiation Chemistry Data Center, August 1971. Paper Copy $6. Microfiche 95 cents.

COO-38-595, Bibliography on Electron Spin Resonance of Radiation Produced Radicals, 1967. Paper Copy $6. Microfiche 95 cents.

COO-38-641, Revised Bibliography on the Radiation Chemistry of Aqueous Solutions. I. Amino Acids, 1968 (Revised August 1969). Paper Copy $3. Microfiche 95 cents.

COO-38-642, Revised Bibliography on the Radiation Chemistry of Aqueous Solutions. II. Carbohydrates, December 1968 (Revised August 1969). Paper Copy $3. Microfiche 95 cents.

COO-38-643, Bibliography on Radiation Chemistry of Alcohols and Phenols, 1968. Paper Copy $6. Microfiche 95 cents.

COO-38-621, Revised Thesaurus for Radiation Chemistry, 1968. (Revised August 1969). Paper Copy $3. Microfiche 95 cents.

COO-36-661, Bibliography on Radiation Chemistry of Alkanes, 1969. Paper Copy $6. Microfiche 95 cents.

The Radiation Chemistry Data Center has both data reviews and compilations in various stages of completion. Topics of the data reviews include:

- Radiation Chemistry of Gaseous Ammonia
- Radiolysis of Ethanol
- Radiation Chemistry of Nitrous Oxide Gas
- Radiolysis of Methanol
- Radiolysis of Ethane
- Radiolysis of Cyclohexane
- Radiolysis of Benzene
- Radiolysis of Water

Topics of data compilations include:

- Selected Specific Rates of Radiation Transients in Aqueous Solution
  - I. Hydrate Electron
  - II. Hydrogen Atom
  - III. Hydroxyl and Perhydroxyl Radicals
- Selected Specific Rates of the Solvated Electrons in Alcohols
- Excess Electrons in Dielectric Liquids

RECOMMENDATIONS FOR DATA COMPILATIONS AND FOR THE REPORTING OF MEASUREMENTS OF THE THERMAL CONDUCTIVITY OF GASES

The National Standard Reference Data System has a twofold objective: first, to improve the quality and productivity of scientific and technological measurements; and second, to provide reliable data needed by scientists and engineers in their everyday tasks. Accordingly, the Office of Standard Reference Data has embarked on a number of activities which will aid in providing basic standards of quality and content and uniformity of presentation. Among such activities, the Office assembled an ad hoc group of specialists in the field of thermal conductivity for the purpose of examining and discussing the problems involved in the compilation and evaluation of data on thermal conductivity of gases. The specifics discussed were format presentations, statistical treatment, theoretical explanations, assessment of the reliability of experimental results, means for promoting uniformity in reporting quantitative results and in obtaining maximum utilization of measured results. The group of specialists included the following: H. Hanley, NBS Boulder; M. Klein, NBS Washington; P. E. Liley, Thermophysical Research Center, Purdue University; S. C. Saxena, Thermophysical Research Center, Purdue University, currently with the Department of Energy Engineering, University of Illinois at Chicago Circle; J. V. Sengers, NBS Washington (currently with the Institute for Molecular Physics, University of Maryland); G. Thodos, Northwestern University; and H. J. White, Jr., Office of Standard Reference Data, NBS. The group compiled a series of recommendations which appeared in an article published in the November 1971 issue of the *Journal of Heat Transfer*. The recommendations are also listed below.

RECOMMENDATIONS FOR COMPILATION OF CRITICALLY EVALUATED DATA

Presentation of Evaluated Data. The "recommended" or "best" or "definitive" data should be presented in tabular form even if equations have been developed which are thought to fit all or part of the data within their reliability. If graphical representation is desirable, it should be given in addition to the tabular material. If at all feasible, the interval of presentation in the tables should allow linear interpolation between points.

Units. The International System of Units (SI units) or units approved for use with the SI units should be used. Where desirable to improve communication or to enhance the usefulness to primary recipients, other units can be expressed by indication of conversion factors, inclusion of parallel columns of converted values, or in other suitable supplementary ways. For further information on SI units see "Policy for NBS Usage of SI Units," *NBS Technical News Bulletin*,[2] Vol. 55, No. 1 (Jan. 1971).

Reliability. Explicit quantitative estimates of the reliability of recommended values should be given. These estimates should take account of the precision of experimental measurements and the estimated magnitudes of systematic errors. A good discussion of methods of treating various degrees of imprecision and systematic error is presented by C. Eisenhart in "Expression of the Uncertainties of Final Results," *Science*, Vol. 160, June 14, 1968, p. 1201. Limits of reliability should also be given for any polynomial or graphical representation that is recommended. Consideration of errors necessarily includes those which might be introduced by manipulative procedures such as extrapolation to an axis or by theoretical approximations in addition to those inherent in the experimental measurements.

Discoursive Material. As a

general rule, the various decisions which have been made and the reasons for them should be discussed. There are several types. The field covered by the monograph should be explicitly defined. If closely related material, which is usually considered simultaneously with the material at hand, is omitted, it may be advisable to point out the omission and its reason. The theoretical basis for analysis, for conversion of primary measurements of one type of data to another, for extrapolation, approximation, or other manipulative procedures should be dealt with fully. Auxiliary data used should be considered as well as primary data. As far as is feasible, the reasons for selecting specific data should be detailed.

Whether original data need to be tabulated or not is a matter for discretion. If there are relatively few, tabulation is probably desirable. Selected individual results should be tabulated, especially in cases where some of them have been difficult to obtain, or, if the evaluator has had to make unit conversions or other transformations, to put the original results on a comparable basis. In any event, it is usually desirable to compare the recommended values with the individual measurements, at least in cases where there are several sets of measurements. This can often be done very effectively by graphical methods. A preferred graphical method, where the grouping of the results allows it, is the "deviation plot," in which deviations of individual results from the recommended values are plotted against some experimental parameter. All pertinent experimental results should be included in a deviation plot, and the limits of reliability of the recommended values should be shown.

Bibliography. As a general rule the bibliography should be as comprehensive as possible. If certain types of results are being omitted, for example those obtained using a certain method or those made using a certain instrument before it was developed to a given sensitivity, the omissions should be mentioned explicitly in the text along with reasons. Otherwise it is desirable to include reference to pertinent measurements even if they are not weighted heavily in determining recommended values. One of the evaluator's tasks is to make it unnecessary for others to search the literature prior to his work. He distills the essence of the literature into his recommended value; but others, approaching with other backgrounds, with other purposes, or in the light of subsequent developments, may wish to rework the data to obtain other numbers or to apply new weighting factors. The evaluator's bibliography and his comments then provide the raw material for their efforts.

RECOMMENDATIONS FOR THE REPORTING OF EXPERIMENTAL MEASUREMENTS

It is obvious that experimental papers are not written for the exclusive use of data compilers or evaluators. However, when the experimenter intends to provide definitive data on a given system, he must perforce consider certain factors. If he reports fully on these factors, he eases the evaluator's job and assures maximum utilization of his efforts.

If at all possible, tables of original measurements should be given. When the number of measurements, or the editorial policy of the journal in which the paper is published, precludes publication in tabular form, the results should be made available either through the American Documentation Institute, directly from the author, or in some other way, and this availability declared in the paper.

The results should be subjected to a detailed error analysis. This analysis should include not only the usual precision measures, but also an analysis of possible systematic errors and of correction factors used.

A full description of experimental details should be given, including specifically the following points:

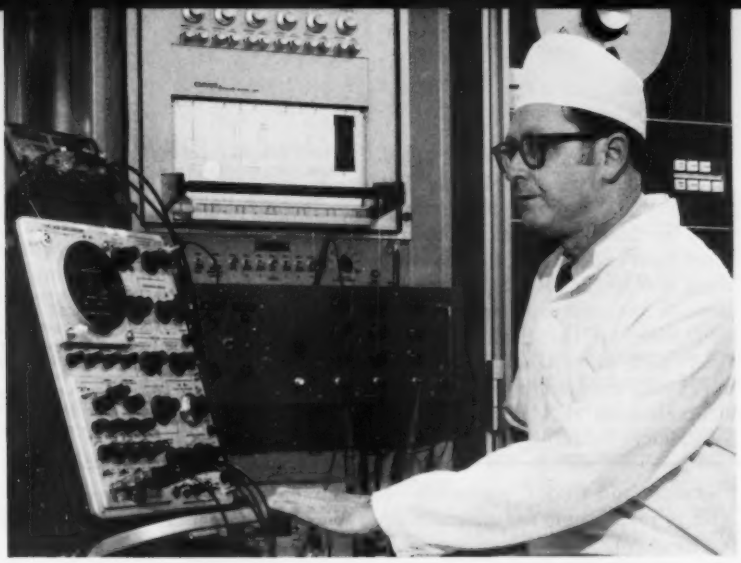
1. A direct experimental assessment of radiative losses.
2. Experimental proof of the absence of convection.
3. A discussion of parasitic conduction and of the efforts made to estimate its magnitude and correct for it.
4. A discussion of the temperature-gradient measurement including specification of the size of the temperature difference and a discussion of the relation of the measured temperature difference and the gradient in the fluid.
5. A discussion of the method of measuring heat flow and its accuracy.
6. Experimental confirmation that the measured thermal conductivity is independent of the magnitude of the temperature gradient (Fourier's law).
7. The determination of the geometrical constants of the system.
8. The geometry of the temperature field.
9. Accommodation coefficients.
10. If the experimental method is a relative method, the calibration and proof of validity of the method.
11. The purity and composition of the sample.
12. Specification of the state variables, including the temperature, at the position in the cell at which the thermal conductivity is measured.

In addition C_p and the equation of state are desirable although not strictly necessary.

[1] Order from National Technical Information Service, Springfield, Va. 22151, by number and price indicated.

[2] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

NOTE: Foreign remittances must be in U.S. exchange and should include an additional one-fourth of the publication price to cover mailing costs.



Sidney Geller makes an adjustment to his apparatus for counting signal dropouts on magnetic tape. The GSA Magnetic Surfaces Laboratory is now using this equipment for counting dropouts on magnetic instrumentation tape sold to Federal users.

NEW TEST FOR MAGNETIC TAPE

New instrumentation for counting dropouts of information recorded on magnetic tape has been developed in the performance measurements laboratories of the Center for Computer Sciences and Technology. S. B. Geller designed the system for use by the General Services Administration (GSA) in appraising tape offered for sale to the U.S. Government. With the new system, GSA can perform the dropout measurements that are required in Federal specifications for both instrumentation and computer tapes.

NBS DROPOUT-COUNTING SYSTEM

The new dropout-counting system produces counts whenever the signal on an instrumentation tape falls below an adjustable threshold level for a minimum length of time, known as the dropout "window." Although dropout window lengths are usually specified to be 10 or 20 μs, they can be continuously adjusted in the new system from 2 to 300 μs for experimental purposes.

The system is unique in that it is a multidropout counter; it adds to the total count the number of window widths contained in each dropout region. The dropout count continues even if the signal level drops to zero. The system can be calibrated with either a tape signal or a sine wave generator and an oscilloscope.

The dropout-counting system can also measure dropouts on three types of computer magnetic tape: 7-track, 1/2-inch tape on which 800 bits-per-inch has been recorded under non-return-to-zero conditions, 9 tracks under these conditions, and 9 tracks at 1,600 bits-per-inch (using the phase encoding system of recording and playback). Dropouts are recorded for amplitudes of less than 50 percent of the reference signal from the first two tapes and of less than 35 percent in the case of the 1,600 bits-per-inch-density recording.

This counting system has been of use in Bureau experimentation on the effects of external magnetic fields on tape-recorded data. The apparatus is also now being prepared for measuring dropouts of magnetic tape in cassettes.

TESTING MAGNETIC TAPE

Magnetic tape offered for sale to the Federal Government is first tested for assurance that it meets minimum standards before being placed on the GSA Qualified Products List (QPL). Later, when shipments of QPL tapes are received by Government agencies, samples are tested to verify that the tape supplied meets the applicable Government specifications.* Testing for all Federal procurements of instrumentation and computer tape is performed by the GSA Magnetic Surfaces Laboratory, located at the NBS Gaithersburg, Md., site.

The Bureau took a big step toward standardized testing and production of magnetic tapes when it made available to the industry Standard Reference Material 3200—a sample of magnetic tape having standard recording and playback characteristics.[1] Mr. Geller and P. Mantek, both of the Computer Center, and N. Cleveland, a Research Associate from the International Business Machines Corp., had developed the original signal amplitude measuring system that enabled them to offer the tape standard.[2] Mr. Geller then designed a new, improved version of this apparatus, which was supplied to the GSA Magnetic Surfaces Laborato-

*Interim Federal Specifications WT-001553 (for instrumentation tape) and WT-0051B (for computer tape).

ry.[3] This equipment is now used by GSA as the reference signal amplitude measurement system for magnetic tapes.

Tape characteristics, other than playback average peak amplitude, measured at the GSA Magnetic Surfaces Laboratory include the presence of dropouts and dropins (loss or addition of data bits because of nonuniformity of or imperfections in the magnetic surface), abrasiveness, longitudinal curvature, skewing, and resistance to cupping. The dropouts and dropins, particularly, were problems in that no instrumentation adequate to measure them was available. Mr. Geller undertook the design of such instrumentation, at the request of the GSA, both for testing tape and for appraising the accuracy of other instrumentation that might become available in the future.

[1] FIPS notes/New reference tape standard, Nat. Bur. Stand. (U.S.), Tech. News Bull. **53,** No. 5, 118 (1969).

[2] Averaging the peak amplitudes of pulses/Instrumentation for evaluating magnetic tape, Nat. Bur. Stand. (U.S.), Tech. News Bull. **53,** No. 10, 224-225 (1969).

[3] NBS instrumentation aids GSA magnetic surfaces lab, Nat. Bur. Stand. (U.S.), Tech. News Bull. **54,** No. 10, 237-238 (1970); and Geller, S. B., Standard Reference Materials: Calibration of NBS Standard Magnetic Tape (Computer Amplitude Reference) SRM 3200 Using the Reference Tape Amplitude Measurement "Process A" Model II, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-29 (June 1971), available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at a cost of 60 cents.

CCST NEWS *continued*

conditions. However, such results themselves imply neither the acceptance nor the rejection of the compiler. Ambiguities resulting from validation testing will be referred to NBS for resolution. The principal criteria for resolving such differences will be based upon interpretations of the Federal COBOL Standard.

Test routines for validating FORTRAN compilers are now under development at NBS. It is planned that validation services for FORTRAN compilers will be initiated in fiscal year 1973.

It is expected that other major compatibility problems facing the Federal ADP community will find their solution through means of cooperative management among the various departments and agencies. This approach will achieve major economies and, at the same time, maximize the utilization of the Government's technical expertise.

DATA CODES REGISTRATION

The Center has developed a set of guidelines for registering both existing data codes and those under development by Federal departments and agencies. These guidelines have been published as Federal Information Processing Standards Publication 19, Guidelines for Registering Data Codes.[2] The guidelines were developed in the context of Office of Management and Budget Circular No. A-86, Standardization of Data Elements and Codes, under which NBS is responsible for maintaining registers of data elements and codes which are in use or under development within the Federal Government. These registers are to be used by systems designers and standards offices as references in initiating implementation actions or development efforts.

After receipt of the code registrations by Federal organizations, NBS will annually publish this information in the form of a Data Codes Register. The guidelines include the use of two new Standard Forms: Standard Form No. 366, Data Codes Registration Form; and Standard Form No. 367, Data Codes Use Report. The latter form will be used whenever another activity uses a code from the register and makes this fact known to the developing or maintaining organization. The maintaining organization will use this information as a basis for informing the using organization of subsequent code changes.

GUIDELINES FOR DESCRIBING DATA INTERCHANGE FORMATS

With assistance from other agencies, CCST has developed a set of guidelines for describing data interchange formats. These guidelines have been published as Federal Information Processing Standards Publication 20, Guidelines for Describing Information Interchange Formats.[2] The guidelines are designed as a reference document for general use throughout the Federal Government and as a checklist for preparing effective documentation of formatted data used in information interchange. The guidelines will facilitate data interchange and reduce the time wasted in attempting to process interchange data for which there is no adequate documentation.

FIPS PUB 12 (INDEX) REVISED

CCST is currently revising the Federal Information Processing Standards Index, FIPS PUB 12, first published on January 1, 1971. The revised edition updates the contents of the earlier edition and will provide the latest available information about standardization activities, and related policy and procedural guideline documents. It also provides an identification of Federal participants in information processing standards committees at Federal, national, and international levels. The index has the objectives of facilitating communication and fostering a more effective utilization of the resources and expertise expended in Federal standardization efforts.

Copies of FIPS PUB 12-1 will be available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 about April 15, 1972.

[1] A set of five papers describing the design and goals of the ARPA Network is contained in AFIPS Proceedings of the Spring Joint Computer Conference (1970), Vol. 36.

[2] FIPS 19 is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 at a cost of 20 cents (SD Catalog No. C13.52:19); FIPS 20 can be ordered from the same source for 25 cents (SD Catalog No. C13.52:20).

STRONGER BOND *continued*

varying from 0 to 270 kgf/cm² (1 kgf/cm² = 9.806 × 10^4 N/m²), well below the A.D.A. recommended minimum value of 315 kgf/cm². Combination of the two foregoing techniques does not effectively overcome their disadvantages.

In this study, cold-curing techniques were used with various experimental bonding methods on three brands of acrylic resin teeth. Duration of application, concentrations and proportions of various solvents and polymerizable solutions were the factors modified in search of an uncomplicated, low-cost system that would form a strong bond between the teeth and denture base at temperatures used in cold-curing procedures. Properly combined and applied, a solvent-polymerizable system swells the surface and permits diffusion of the polymerizable material. On polymerization a network of interweaving polymer chains is formed, resulting in a tensile strength of up to 80 percent of that of the parent plastic. The strength of the bond is dependent upon the degree of penetration of the solvent and the strength of the interwoven polymer chains.

Applications of the various solutions were made directly on the necks of thoroughly cleaned teeth. After the exposure time had elapsed, any excess solution was removed and the denture bases poured or packed over the wet teeth. All bonds produced were tested for tensile strength. Teeth treated with solutions that produced bonds meeting the A.D.A.'s minimum strength requirements were then subjected to hardness and craze resistance tests. All the teeth so tested met the A.D.A. specifications for those properties.

The most successful bonding procedures were (1) the application of a solution of CH_2Cl_2, 50 percent by volume, and MMA (cold-curing), 50 percent by volume, the MMA containing 10 percent by weight of PMMA, for 5 minutes and (2) treatment with a solution of CH_2Cl_2, 50 percent by volume, and MMA (cold-curing), 50 percent by volume, for 4 minutes. The second method produced higher strength bonds with a smaller coefficient of variation, 431 kgf/cm² ± 10 as compared to 356 kgf/cm² ± 26 for the first procedure.

The response of oral tissues to dentures processed using this procedure has not been tested. However, any tissue response is most unlikely because of the low toxicity to ingestion (minimal lethal dose in dogs = 3,000 mg/kg) and the low amount of CH_2Cl_2 (less than 20 mg) in any set of complete upper and lower dentures. In addition, its high evaporation rate would reduce the free CH_2Cl_2 before the dentures were worn by a patient.

[1] Rupp, N. W., Bowen, R. L., and Paffenbarger, G. C., Bonding cold-curing denture base acrylic resin to acrylic resin teeth, J. Amer. Dent. Assn. **83**, 601-606 (Sept. 1971).

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Annual subscription: Domestic, $3; foreign, $4. Single copy price, 30 cents. Available on a 1-, 2-, or 3-year subscription basis. SD Catalog No. C13.13:56.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $9.50; foreign, $11.75. Single copy price varies. SD Catalog No. C13.22/sec.A:74.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.B:74.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25. SD Catalog No. C13.22/sec.C:74.

NBS BIBLIOGRAPHIC SUBSCRIPTION SERVICES

Cryogenic Data Center Current Awareness Service (Publications and Reports of Interest in Cryogenics). A literature survey issued weekly. Annual subscription: Domestic, $15; foreign, $20.

Liquefied Natural Gas. A literature survey issued quarterly. Annual subscription: $15.

Superconducting Devices and Materials. A literature survey issued quarterly. Annual subscription: $15.

Send subscription orders and remittances to the Cryogenic Data Center, Room 2022, Cryogenics Building, National Bureau of Standards, Boulder, Colo. 80302.

Electromagnetic Metrology Current Awareness Service (Abstracts of Selected Articles on Measurement Techniques and Standards of Electromagnetic Quantities from D-C to Millimeter-Wave Frequencies). Issued monthly. Annual subscription: $100 (special rates for multi-subscriptions). Send subscription order and remittance to the Electromagnetic Metrology Information Center, Electromagnetics Division, National Bureau of Standards, Boulder, Colo. 80302.

CURRENT ISSUES OF THE JOURNAL OF RESEARCH

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West, E. D., Case, W. E., Rasmussen, A. L., and Schmidt, L. B., A reference calorimeter for laser energy measurements.

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J. Res. Nat. Bur. Stand. (U.S.), **76A2** (*Phys. & Chem.*) (March-April 1972), SD Catalog No. C13.22/sec.A:76/2

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Garvin, D., Guidelines for the reporting of numerical data and experimental procedures.

Goodwin, D., and Prydz, R., Densities of compressed liquid methane, and the equation of state.

Huie, R. E., and Herron, J. T., Rates of reaction of atomic oxygen III. Spiropentane, cyclopentane, cyclohexane, and cycloheptane.

Shadmi, Y., and Caspi, E., Theoretical investigation of the odd configurations of Ni II.

Shumaker, J. B., and Popenoe, C. H., A study of equilibrium in argon arcs.

Sieck, L. W., Lias, S. G., Hellner, L., and Ausloos, P., Photoionization of C_4H_8 isomers. Unimolecular and bimolecular reactions of the $C_4H_8^+$ ions.

The characterization of linear polyethylene SRM 1475.

I. Introduction. C. A. J. Hoeve, H. L. Wagner, and P. Verdier.

II. Determination of total methyl content by infrared spectrophotometry. J. E. Brown.

III. Density determination. J. E. Brown.

IV. Melt flow rate. J. R. Maurey.

V. Solution viscosity measurements. R. G. Christensen.

VI. Preparation of calibrating fractions. R. G. Christensen.

VII. Differential refractive index of polyethylene solutions. H. L. Wagner.

VIII. Light scattering studies on polyethylenes in 1-chloronaphthalene. L. J. Frolen, G. S. Ross, A. M. Wims, and P. Verdier.

IX. Number average molecular weight of fractions by membrane osmometry. J. E. Brown and P. H. Verdier.

X. Gel permeation chromatography. G. Ross and L. Frolen.

OTHER NBS PUBLICATIONS

Simmons, J. A., deWit, R., Bullough, R., Editors, Fundamental aspects of dislocation theory. Proceedings of a Conference held at the National Bureau of Standards, Gaithersburg, Md., April 21-25, 1969, Nat. Bur. Stand. (U.S.), Spec. Publ. 317, Vol. 1, 752 pages and Vol. 2, 624 pages (Dec. 1970). Price $8.25 per set of 2 volumes, sold in sets only, SD Catalog No. C13.10:317.

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